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Control System Scope and Job Activity in Various Designing/EPC & Process Industries

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(Abstract) This article deals about the role / job activity of instrumentation & control of various EPC / EPCM (Engineering, Procurement, Construction & Maintenance) groups / designing companies. EPC groups designs the process plants like Raffineries, Power Plants, Steel Plants & Sugar Mills etc. The EPC companies have various Departments (Electrical, Mechanical, Instrumentation and Control, Procurement & Civil). All of these Departments work together for a project to be executed. INSTRUCALC 6.2 is the latest version of the Instrucalc software that can be used for accurate sizing of more than 50 different instruments. The latest standard "IEC 1131-3″ has been tried to merge PLC programming languages under one international standard. Presently, we have PLCs that are programmable in function block diagrams, instruction lists, C and structured text simultaneously. Distributed control system integrates the PLCs and process controllers of a process line into a coordinated and interactive system enabling us to manage the process as a complete system with control over the inter relationship of the various subsystems. INtools provides a single source of plant information that can be easily accessed and updated and ensures consistency across the different instrument tasks and deliverables.

Keywords: DCS; PLC; P & ID; SCADA; Smart Instrument; Temperature Measurement; Flow Measurement; Pressure Measurement; INtools; InstruCalc.

1. Control System Scope and Job Activity

Control System Engineering deals with Techniques and Equipment being used for Measurement of Process Parameters such as Pressure, Level, Flow, Temperature, Speed, Humidity, Position etc [1].

1.1 Process Control Chain

The Control Equipment consists of any one or combina tions of following:
Controllers, Indicators, Recorders etc.
DCS (Distributed Control System).
PLC (Programmable Logic Controllers).
SCADA (Supervisory Control And Data Acquisition System).

In Control Systems (Fig.1), action starts from initial stages of a Project and goes on till it ends. The following major activities are performed :

(i) Providing inputs during generation of P&IDs(Piping and Instrument Diagram) and Control Schemes to Process discipline.

(ii) Preparation of various specifications like instrument and control philosophy, safety and shutdown philosophy, instrument design specification etc.

(iii) Identification of various types of instruments from P&IDs and start preparing Instrument Index.

(iv) Preparation of instrument specification in the form of Instrument Data Sheet with inputs from Process data sheets.

(v) Performing sizing calculations for Control valves, Safety Relief valves, orifice plate and rupture discs. Vibration Calc

(vi) Utilizations for Thermo wells.

(vii) Issue of instrument specification for procurement.

(viii) To Evaluate quotations received and make technical recommendations for purchase [1].

1.2 Deliverables of Control System Department

Instrumentation Index.
Instrument Location Plan.
Bill of Material.
Nozzel Elevation Drawing/ Vessel Sketch/ Level Sketch.
Logic Diagram.
Control Room Layout.
Purchase Requistion.
Functional Schematics.

2. Measurement of Process Parameters

Following Parameters are measured by different instruments
(i) Level Measurement by
Gauge Glass
Ball Float
Differential Pressure Level Detectors
Temperature Measurement by
Resistance Temperature Detector (RTD)
Thermocouples
Flow Measurement by

Flow Nozzle
Orifice
Pitot Tube
Annubar
Venturi Tube
Ultrasonic Flowmeter
Pressure Measurement by
Bourdon Tube
Diaphragm seals
Bellow capsule

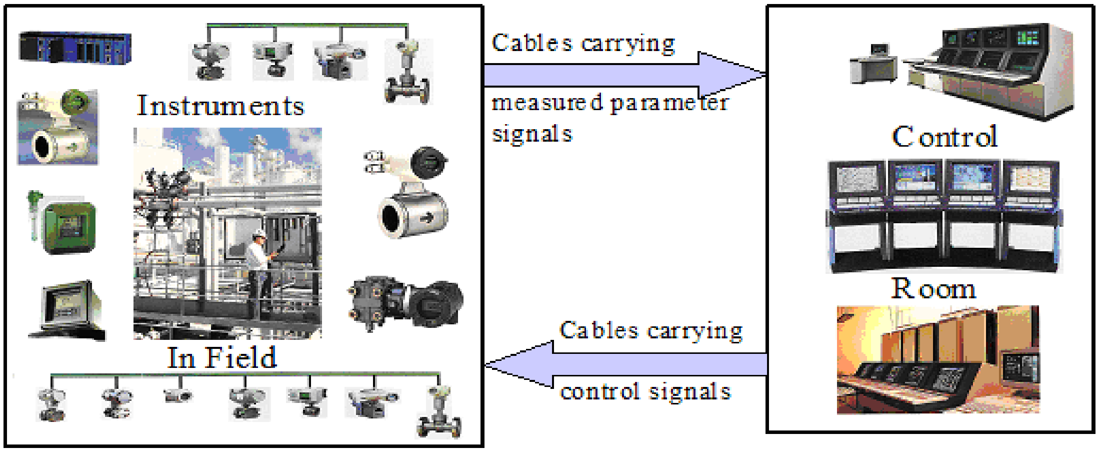


Fig.1 Control System – The Complete Picture

3. P & ID (Piping and Instrument Diagram)

A P&ID (Fig.2) is a symbolic representation of process flow, interaction and control. In P&ID symbols clearly indicate what is required so as the design proceed smoothly and construction and operations have a clear understanding of the plant design basis. In flow diagrams there is a schematic representation of the equipment, piping and instrumentation used in a process plant. They are used to convey information to the design disciplines and show the overall plant design. The main types of flow diagrams used are the PFD (Process Flow Diagram), MFD (Metallurgical Flow Diagram), P&ID (Piping & Instrument Drawing), UFD (Utility Flow Diagram) and AFD (Auxiliary Flow Diagram).

A P&ID contains detail information about the following:
(i) Process & Utility streams
(ii) All Process Equipments
(iii) Complete Instrumentation
(iv) Analog & Digital Control Signals

4.Programmable Logic Controller(PLC)

A Programmable Logic Controller (PLC) or Programmable Controller or Logic box is an electronic device used for automation of industrial processes, such as control of machinery on factory assembly lines (Fig.3). Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed or non-volatile memory.

A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result (M. A. Laughton, D. J. Warne (ed,2003).

A PLC system consists of the following modules (W. Bolton,2009)
I/O module
Network connections
Controller
Communication
Software

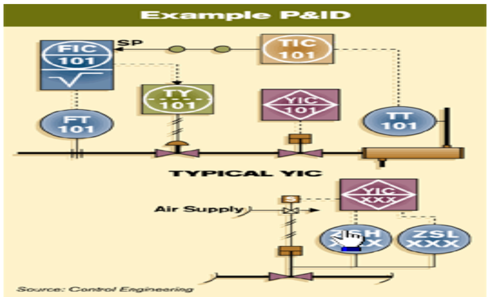


Fig.2 Example P&ID

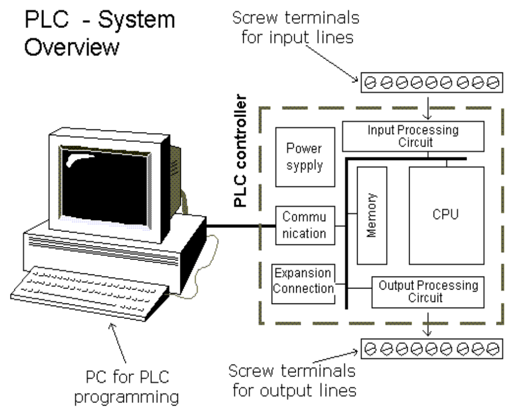
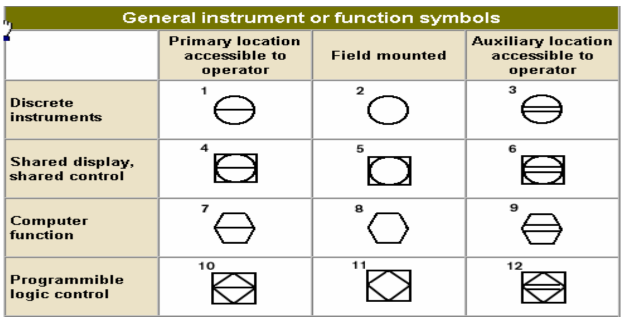


Fig.3 PLC-System Overview

Display Module
Digital & Analog Signals
Users Interface



General instrument or function symbols	Primary location accessible to operator	Field mounted	Auxiliary location accessible to operator
Discrete instruments	1	2	3
Shared display, shared control	4	5	6
Computer function	7	8	9
Programmible logic control	10	11	12

Fig.4 General instrument or function symbols

PLC manufacturers

ABB, Koyo, Honeywell, Siemens, Modicon, Omron, Allen-Bradley, General Electric, Panasonic (Matsushita).

5. Distributed Control System (DCS)

A distributed control system (DCS) refers to a control system of a manufacturing system, process or any kind of dynamic system, in which the controller elements are not central in location (like the brain) but are distributed either geographically or functionally or both. In this entire system may be networked for communication and monitored by using single /multiple communication link. The DCS typically uses computers (usually custom designed processers) as controllers and uses both proprietary interconnections and protocols for communication and input & output modules form component parts of the DCS. The processor receives information from input modules, execute the information and sends information to output modules. The input modules receive information from input instruments i.e. field instruments viz; transmitters & switches, in the process and output modules transmit instructions to the output instruments in the field instruments viz; control valve etc (Fig.4&5).

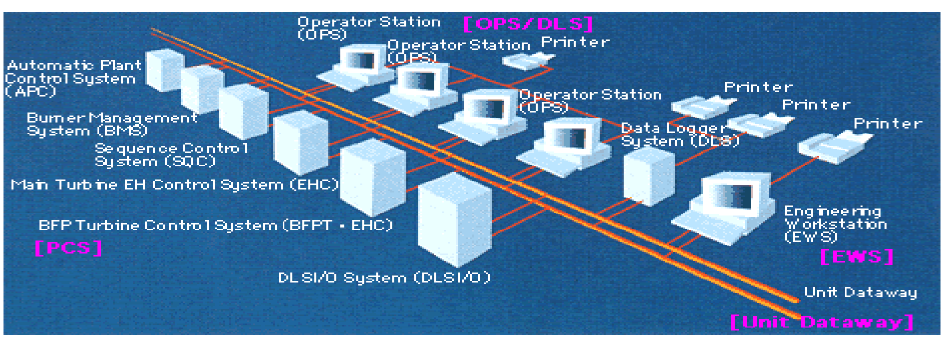


Fig.5 Distributed Control System (DCS)

A distributed control system integrates the PLCs and process controllers of a process line into a coordinated and interactive system. It enables us to manage the process as a complete system, with control over the interrelationship of the various sub-systems. DCS improve the overall efficiency and quality of plant [2].

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System Components of DCS includes:

1. I/O module
2. Operator Station (OPS)
3. Data Logger System (DLS)
4. Engineering Work Station (EWS).

Major Vendors are

ABB, YOKOGAVA, Honeywell, HITACHI, FOXBORO.

6. Smart Instrument

Smart device is a microprocessor based device that can be programmed and has a memory that can perform calculations; perform self-diagnostics; reports faults; and can be communicated with from a remote location (Fig.6).

Most of the smart instruments use HART communication protocol. Smart instruments have the following features:

(i)Re-ranging
(ii)Signal-conditioning
(iii) Self-diagnosis

There are distinct advantages in using smart instruments:

(i) It speed up the troubleshooting time between the identification and resolution of problems.
(ii) It avoids the high cost of unscheduled shutdowns or process disruptions.
(iii) It reduces spares inventory and device management costs.
(iv) It quickly verify and validate control loop and device configuration.
(v) It uses remote diagnostics to reduce unnecessary field checks.

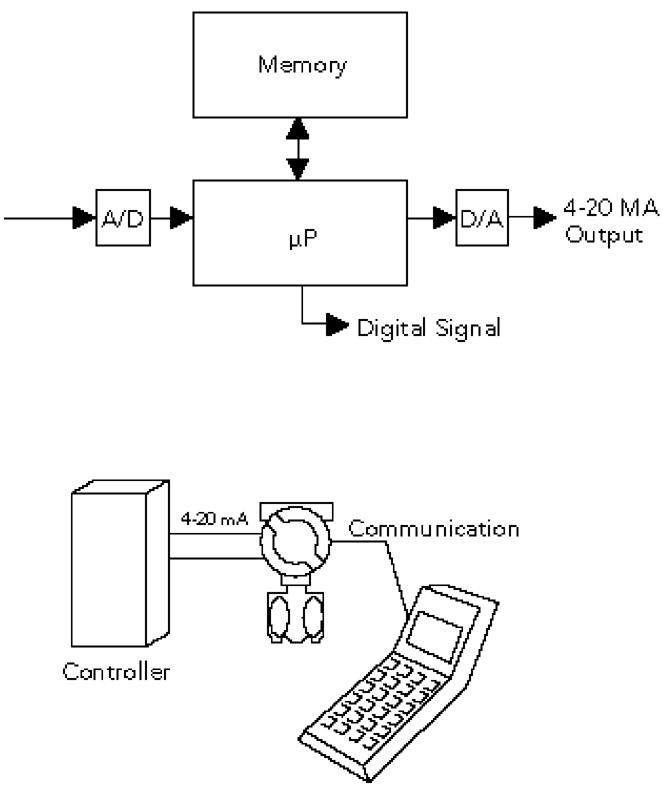

Fig.6 Smart instrument

6.1 Software Used: Following soft wares are used:

6.1.1 Smart Plant Instrumentation (SPI)

In SPI control Systems are mission-critical systems for safe and efficient plant operation. Here, timely access to accurate plant information is crucial, whether we are facing routine maintenance or instrument failure. Intergraph INtools (Fig.7) are the industry-leading instrumentation solution that helps us to prevent failure by better managing and storing the history of our control system. We can prevent unscheduled shutdowns by better planning maintenance.INtools provides a single source of plant information that can be easily accessed and updated and ensures consistency across the different instrument tasks and deliverables. INtools pays for itself by providing information quickly and accurately, since there is a single source for the data, eliminating the need to search for information in multiple locations.

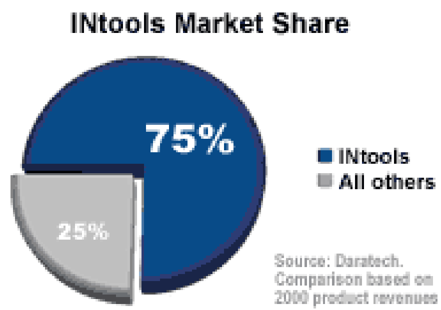

Fig.7 INtools Market Share

Designed for plant owner/operators and engineering firms, Intergraph INtools™ is an instrument engineering application that allows you to design and manage instruments. INtools manages all phases of design, and Intergraph, continues to enhance and develop INtools modules for plant operations, construction, and commissioning. Because all data is derived from the same database, INtools provides consistency across tasks. Capabilities include vivid visualization of design through standard reporting tools and easy data entry with tiled spreadsheets that provide views of multiple sheets. INtools also saves work hours by eliminating duplicate data entry (Gregory K. McMillan and Douglas M. Considine (ed,1999).

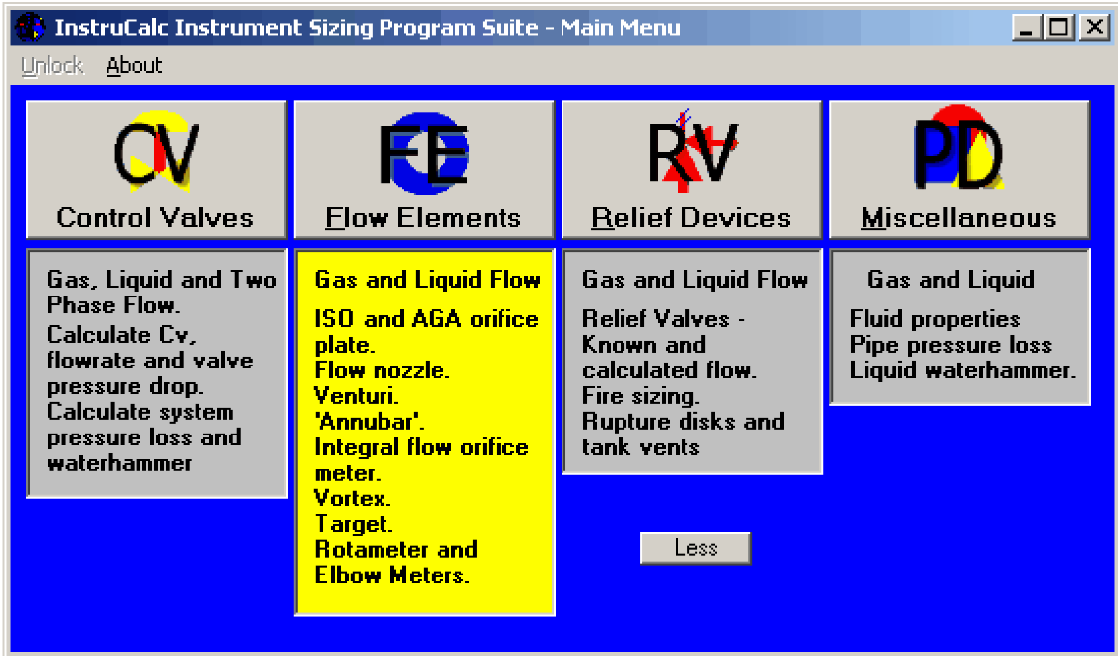

Fig.8 InstruCalc Instrument Sizing Program Suite-Main Menu

6.1.2 Instrument Engineering Calculation (InstruCalc)

InstruCalc 6.2 (Fig.8) is the latest version of the instrucalc software that can be used for accurate sizing of more than 50 different instruments. InstruCalc 6.2 calculates sizes of
(i)control valves
(ii)flow elements
(iii)relief devices
(iv)produces data sheets for calculated items
(v) prepares instrument summaries
(vi)uses data sheets as a database for generating report
The Control valve and Flow element modules can calculate, display and print graphs of our calculations. InstruCalc 6.2 allows us to select any set of engineering units, including our own customized set. Units can be mixed, matched and changed in the middle of a calculation.InstruCalc 6.2 calculates process data at flow conditions for 54 fluids in either mixtures or single components and 66 gases in either mixtures or single components. Files can be updated with additional users fluids and gases. InstruCalc 6.2 calculates the orifice size, flow rate or differential range, which enables the user to select the flow rate with optimum accuracy. It provides the recommended size and corrects the orifice size accordingly. Process data can be converted individually or jointly with a simple "click of the mouse".

In it graphs for Control Valves and Flow Elements calculations have been added. The programs can calculate, display and print graphs of the calculations. Graphs available for Control valves are: valve and flow; valve pressure drop and flow; linear trim; and, equal percent trim. Flow Element graphs include: flow and differential [3,4 and 5].

6.1.2.1 Control Valve Sizing (Fig.9)

Following three programs are available, each for standard and low flow valves:
(i)Liquid Flow
(ii)Gas Flow
(iii)Two Phase Flow
Following three options for each Valve Calculation are:
Calculate Valve Size
Calculate Flow Rate
Calculate Valve Pressure Drop
Following three cases are provided for each calculation:
Maximum Flow
Normal Flow
Minimum Flow
Aids for the calculations are:
Typical Valve Data Tables
Fluid Properties at Flowing conditions
A Program to calculate the valve pressure drop is available in the Piping System. After using the above for normal flow to determine the valve size, scroll bars will change the flow, recalculate the data and determine the maximum and minimum flows that the piping system will allow. The programs have a data base of typical valves so that different valve data can be entered into the calculation in order to make the best selection. Several attempts and calculation are made until a valve style and size is selected which has the range ability and does not have cavitation or noise problems. When a final selection is made the exact manufacturers' data can be entered for a final calculation. Finally, for liquid valves in long piping systems, option for the minimum closing time are taken, this is the water hammer program to determine if a special closing time is required to avoid water hammer.

6.1.2.2 Sizing Philosophy

Each manufacturer has its own formula for determining the valve size, the valve noise and the cavitations characteristics. This program uses the ISA sizing formulas; it uses the Masoneilan noise prediction method and incipient cavitation technique. The object of the program is to determine the valve size, the cavitations, flashing and noise problems and prepares a data sheet suitable for bid purposes. Some manufacturers may differ from these conclusions, usually the variations are minor and do not change the size and style. Occasionally, the noise and cavitations characteristics will differ so that engineering judgment may be called for. The failure of a valve because of cavitations erosion can be extremely expensive. Sometimes a change in body style, or hardened trim is sufficient to eliminate the problem (Fig.10)

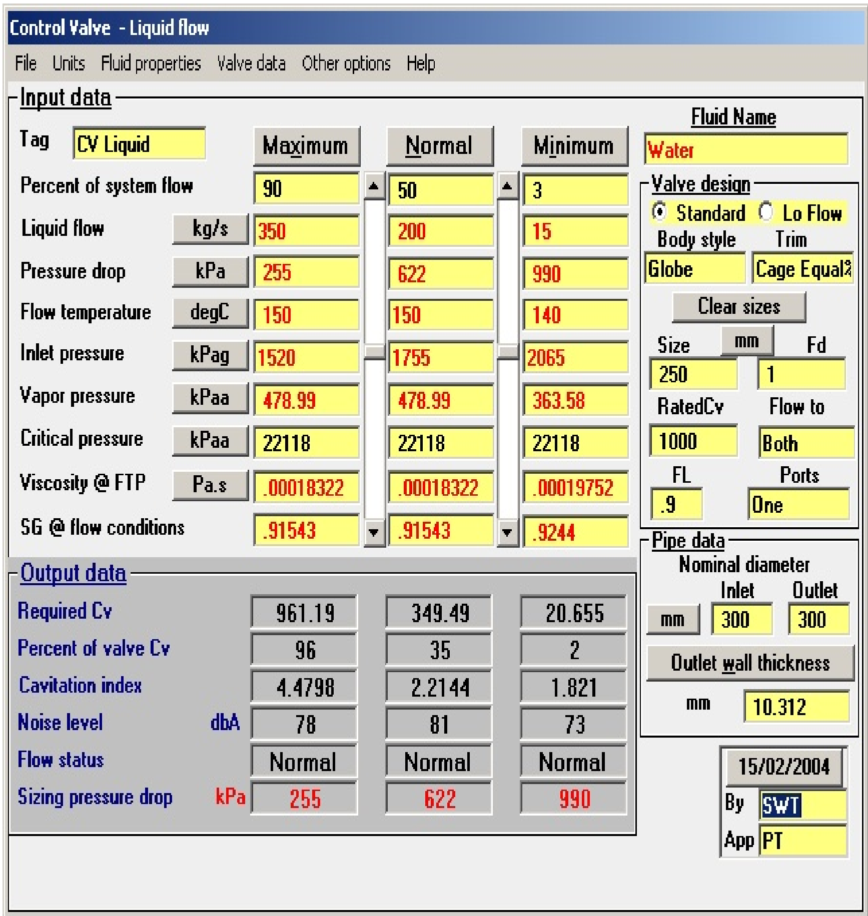

Fig.9 Control valve-liquid flow

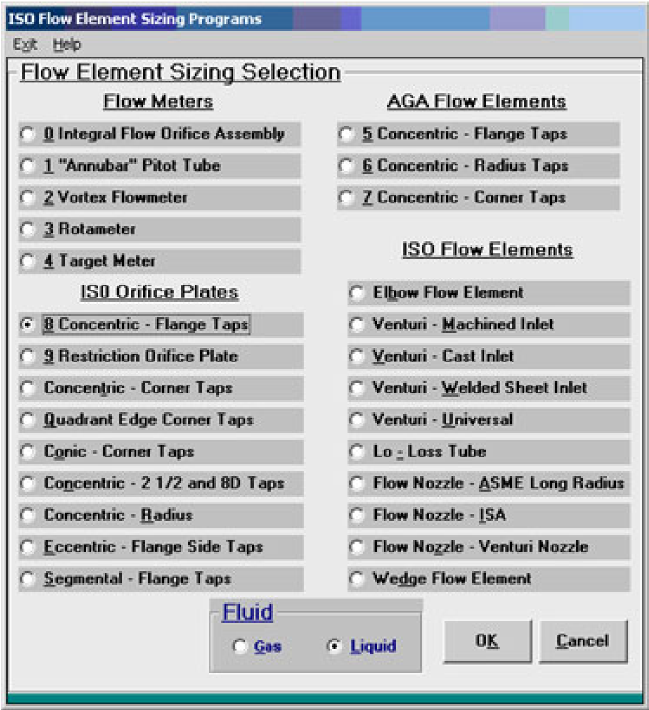

Fig.10 ISO Element Sizing Programs

7. Datasheet (Specification sheet/ Spec. Sheet/ RFQ)

A Datasheet is a document, or its electronic equivalent that details the statement of parameter or properties prescribing the design basis, construction, materials and performance of an instrument to be supplied.

Datasheet forms are generally comprised of three parts:

Operating Parameter
Device Specification
General or Specific Requirement.

Following are inputs for the Datasheets:

P&IDs,
Process Datasheet,
Line List,
PMS, Vendor Data,
Sizing Data,
Vessel GA Drawing/ Vessel Sketch,
Project Specific Data.

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